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Common Storage of Vegetables: A Discussion of the Factors Involved

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Sundried Vegetables

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COMMON STORAGE OF VEGETABLES

A DISCUSSION OF THE FACTORS INVOLVED

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Everyone realizes that growing plants are living things which require proper living conditions in the way of water, light, air, and food materials in the soil; and that under unfavorable conditions plants die. But it is rather common to think of the so-called hardy vegetables—potatoes and the root vegetables—as inanimate material which can be put away for indefinite periods and expected to remain in an unchanged condition. And when we find our stored vegetables do change and deteriorate, we are apt to feel that we have been cheated. As a matter of fact, vegetables are living organisms as much as growing plants, and they demand proper living conditions, without which they will not remain in a healthy condition.

Most of the hardy vegetables may be classed as storage organs designed by the plant as a means of supplying food to the young growing plant of the next generation, and when mature they pass through a rather extended resting period until it is time for the new plant to begin to grow. When we use these vegetables for food, we are really stealing the unborn plant's legacy and appropriating it to our own use. This dormant or rest period always occurs in the life of the storage organ; potatoes dug from the ground will not sprout immediately without special and vigorous treatment. But the length of the rest period may vary from a few weeks at a high temperature, to six months or more if the vegetables are in cold storage. At the end of the rest period, when growth is resumed profound changes go on within the storage organ which render it unfit for food. It is, therefore, highly desirable to prolong the storage period, and since its length is increased in proportion as the temperature is lowered, we have here one of the chief reasons for low temperature storage.

There is another reason. These hardy vegetables are well stocked with food material—largely starch and sugar—when they are harvested. While they are resting they keep themselves alive by using up some of this stored material; they take in oxygen through openings in their skin and breathe out carbon dioxide just as animals do, the carbon dioxide coming from the oxidation of the stored starch and sugar. It is a process similar to that which goes on in a fasting animal, when the body stores are depleted and the animal grows thin because food is not being supplied from outside and must be found inside to make good the energy requirement of life. As long as an organism lives, the life processes demand that energy be supplied from somewhere, and so the vegetable uses up in maintaining its own metabolism, those very materials which we wish to use as food. Stored vegetables lose weight, largely for this reason. It has been found that the rate of metabolism and consequently, of carbon dioxide evolution of plants is much higher with high temperatures than with low. In fact, by reducing the temperature ten degrees (centigrade) one can very nearly halve the amount of carbon dioxide being given off, which means that only about one-half as much sugar or starch is being used up. A bushel of potatoes placed in a shed, say, at fairly hot summer temperature—30° C.—will lose a certain amount of CO₂ in each hour; if instead they are stored at 20° C., they will lose only one-half as much in an hour; at 10° C. they will lose one-fourth as much, and at 0° C. (freezing) they will lose (roughly) only one-eighth as much CO₂ as at 30° C., which means that their stored food should last about eight times as long in cold storage as at summer room temperature.

There are, then, two very definite reasons why vegetables cannot be expected to keep at high temperatures: the heat (1) brings on premature sprouting, and (2) causes rapid depletion of stored carbohydrates.

It may be that some day some one will discover a chemical treatment which will arrest these natural processes and make it possible to store hardy vegetables unchanged at room temperature. But so far attempts along that line have been unsuccessful. Recent experiments have shown that things like ether, chloroform and ethylene, which are anaesthetics for animals, stimulate the activity of plants, increasing their respiration rate and even breaking up the rest period in dormant organs and inducing early sprouting. Such treatment is being advocated for seed potatoes where it is desirable to replant soon after digging. The action of these chemicals is a step in the wrong direction from the standpoint of one who wishes to prolong storage life.

In 1901 Morris published a bulletin from this station in which he described some interesting storage experiments; he dusted potatoes with such things as quicklime, copper sulfate, common salt, and dipped others in melted paraffin, Bordeaux mixture, formaldehyde solution, and ammoniacal copper carbonate solution. The treated potatoes he stored away carefully, hoping that time would show that at least one of the modes of treatment was a magical elixir of life which would cause potatoes to keep in spite of high temperatures. But he was disappointed; all the potatoes rotted, and the specially devised treatments only hastened the rotting.

The only chemical treatment which has proved at all successful in extending the storage life of fruits and vegetables, is the use of atmospheres containing certain amounts of carbon dioxide. Apples have been shown to keep twice as long in an atmosphere containing 10% carbon dioxide and 11% oxygen, as in air (which contains 21% oxygen and less than 1% carbon dioxide). In this gas mixture apples keep as well at 64° F. as they do at 34° F. in air. But, above 50° F. such gas mixtures become ineffective, and even detrimental. Although interesting, gas storage will probably never be of use to the small farmer because it calls for air-tight storage rooms where the composition of the atmosphere can be carefully controlled.

Much time has been given to the determination of the ideal storage temperatures for the common vegetables, and it may be well to summarize the results. Most vegetables, especially the root crops, do best at 36-40° F., temperatures above 50° are very unfavorable. Potatoes do best at 35° to 40° F. with rather high humidity. Onions like a dry air and a temperature of 32° to 36° F. but may be kept at a higher temperature if the ventilation is good. The ideal temperature for cabbage is 32° to 36° F. in a moist atmosphere. Parsnips give best results when kept at 34° F. Beets appear to keep better at cellar storage (50° F.) than in actual cold storage, particularly if they are packed in sand or sawdust. Carrots do better packed in dry sand than in moist sand, and prefer a lower temperature than the beets. Celery keeps well at temperatures so low that the outer stalks actually freeze.

Sweet potatoes (like squash and pumpkin) do best at higher temperatures. After the vines are cut the sweet potato refuses to go into a dormant condition until it has brought about the transformation of a good part of its starch into cane sugar. This process goes on no matter what the storage temperature, but at higher temperatures the process is completed much more rapidly, and it has been found to be advantageous to submit the freshly dug potatoes to a temperature of 80-90° F. for from ten to fourteen days. During this time large amounts of moisture and carbon dioxide are given off and adequate ventilation must be provided. After being cured, sweet potatoes are stored at 55° F. in air dry enough that moisture will not be deposited on them.

Besides temperature control there are some other things to be taken into consideration in storage. For one thing light should be excluded because its presence has a deleterious effect. Another factor is ventilation. The point has already been stressed that vegetables take in oxygen and give off carbon dioxide; they must continue to do so in order to remain in a healthy condition. Provision must therefore be made for all the vegetables to come in contact with sufficient fresh air to supply the oxygen which they need. Close packing in bins or otherwise, may cause actual smothering of some of the material. Potatoes sometimes blacken at the heart due to the lack of oxygen. This happens most readily when potatoes have been exposed to higher temperatures, where the rate at which oxygen is required is much increased; oxygen is believed to be used up so rapidly under these conditions that none of it can penetrate into the cells in the exterior of the potato, and here asphyxiation occurs, with death and blackening of the tissue. This condition is apt to occur during shipping but may occur at any time when the oxygen supply is insufficient. Another factor in ventilation is the removal of the products of respiration; carbon dioxide and water vapor are being given off all the time and should be removed not only because they take the place of the much needed fresh air, but also because their presence in too large amounts may have a harmful effect on the vegetables. In the discussion of gas storage it was pointed out that the concentrations of carbon dioxide, and of oxygen, and the temperature, must be very carefully controlled in order to avoid harmful effects due to excess carbon dioxide. Thorough ventilation is always safe; storage in artificial atmospheres is safe only under special conditions. It is probable that pit storage is an example of this very thing. Vegetables in pits sometimes keep exceptionally well, at other times they all rot. If the carbon dioxide from the vegetables and from the decaying grass and straw surrounding them happens to give an atmosphere of favorable composition, and if at the same time the temperature is low and the humidity not too high, the results may be very satisfactory. If on the other hand, the carbon dioxide content of the atmosphere is too high, or if the temperature rises, or the humidity is too great, rotting will be hastened. There are so many variables, all uncontrolled, that it is impossible to depend on pit storage to give uniformly good results, especially in this part of the country where the hot weather extends late into the fall.

There are other products which are given off in very small amounts by fruits and vegetables, volatile products connected with their characteristic odors, which are believed to be injurious if they are allowed to collect, and which constitute another reason for ventilation.

I have attempted to point out in a general way the requirements which must be met if vegetables are to be stored satisfactorily. In proportion as they are stored under proper conditions, they can be expected to keep long and well. If the storage temperature is higher than the optimum, they will not keep so long nor in so good a condition. This is an edict of nature, and at present we know no way of getting around it. What then are the prospects for common storage of vegetables in Oklahoma? Frankly, they are not good, unless one can so construct caves and cellars, insulated from outside heat, that satisfactory temperatures can be obtained. This would have to be a matter for experimentation. It is questionable whether any cave or cellar could give a very low temperature during the hottest months in view of the fact that in Rochester, New York, not one cellar out of 253 had a temperature below 55° F. during the hot weather. With late gardens, the chances of satisfactory storage will be greatly increased. Temperature is always the vital factor.

SUNDRIED VEGETABLES

MARJORIE BENOY AND GRACE STEININGER

In the preceding discussion some of the necessary conditions for satisfactory storage of common vegetables have been pointed out. Since it is obviously difficult to meet the low temperature requirements in this part of the country unless properly constructed cellars are at hand, more stress must be laid on other methods of preservation.

Canning is widely and satisfactorily used. The long hot days, and the dryness of the atmosphere, suggest that sun-drying might also be used to advantage. This method of preserving food is, of course, older than civilization itself, but, although new processes have seemed to supercede it, it still has some things which would appear to commend it. No doubt in many parts of the country the preservation of foods by drying them in the sun is something not to be thought of except as an extremity measure. But in Oklahoma we find that when summer becomes established, the vegetable produce in the spring gardens matures rapidly and the housewife finds suddenly that she has on her hands more things than the family can consume, with common storage out of the question at the prevailing temperature, and the prospect ahead of the garden's being burned up within a few days. How desirable it would be, then, to make use of that hot dry weather which is about to destroy the garden, to preserve what has reached maturity! From this point of view, last summer we felt that it would be worth while to make a few experiments in sun-drying in a simple way using the material at hand.

We had two simple racks made to fit onto the legs on the outside of the window; their longest dimension was the width of the window, and they were 18" wide by 4" deep, open at the top and covered with galvanized wire in the bottom. One was attached to a south, and one to a west window of the laboratory, which happens to be in the third floor of a building which is surrounded by grassy lawns, so that there was almost no dust. Some trays made of light pieces of wood with mosquito netting tacked to the bottom, which could be easily lifted in and out, were used for holding the material to be dried. Galvanized screen-wire cut to fit the racks was fastened in place with thumb tacks after the trays had been placed on the rack. Of course, a hinged top, screen covered, would have been more convenient. The location of the racks was very satisfactory because there was usually a good breeze blowing through the drying material. Two days gave an apparently well dried product, but three were usually allowed.

Preparation of Material

Materials were prepared for drying as follows: Corn was cooked in salt water until the milk had set; as soon as it was cool enough to handle it was cut from the cob and placed on the racks.

Carrots were parboiled whole in salt water from 7 to 10 minutes, sliced or chopped and dried; some were scraped after parboiling, then sliced and dried, and this gave a better-looking product.

Tomatoes were sliced raw in very thin slices. By having the slices thin and laying them carefully flat on the mosquito netting, they appeared to dry satisfactorily, giving an attractive dark red product.

Cabbage was shredded, placed in a wire basket and blanched 2 minutes in boiling water; one portion was then washed in cold water containing about 20 drops of strong ammonia water per quart; while the remaining material was similarly rinsed in a cold water solution containing two heaping tablespoonfuls of baking soda per gallon. The two portions were dried separately,

but since there was no difference in the appearance of the dried product, they were later combined.

White Bermuda onions were cut in thin slices and dried without cooking.

Red pimentos and green mango peppers were cut in small pieces and dried without cooking.

Beets were scraped, cut in slices, and blanched 2 minutes in boiling salt water.

Beet leaves (best portion) were blanched 2 minutes and then washed in a cold baking soda solution, to preserve the green color.

Tender young pods of okra were blanched whole in boiling salt water for 2 minutes, washed in cold water, sliced and dried.

Potatoes were boiled in the skins until soft, peeled, mashed and dried.

All material was dried until it appeared to be thoroughly dry and gave no indication of moisture on being pressed between the fingers or broken. To sterilize against insects which might have found access to the material during the drying process and deposited eggs, most samples of dried vegetables were placed in an oven and brought to a temperature of about 180° F. (decidedly hot to the touch) before being stored.

A variety of containers may be used for storing dried material, cloth or paper bags sometimes proving satisfactory. It is necessary to exclude all insects and probably desirable to keep out light. Tin coffee and baking powder cans and glass jars were used in our work, with storage in a dark cupboard. It seems to be a matter of question as to whether containers should be airtight. Apparently dried material at first tends to lose or to gain from the surrounding air small amounts of moisture; after a short time it reaches equilibrium with the air, and takes up no more moisture even if exposed to the air. It is desirable to let the material reach this condition. In our work we accomplished this by pouring the material out into a pan, mixing and returning it to the original container, several times during the first week after drying.

Our dried material was stored in a dark closet in the laboratory and held there for at least six months and then submitted to cooking tests.

Cooking Tests

Five portions of each vegetable were weighed out; the first sample was soaked one hour, the second two hours, and the third overnight, before being cooked; the fourth sample was cooked without soaking in cold water and the fifth was cooked, without soaking, in hot water. Those vegetables which were soaked were cooked in the same water in which they had been soaked. All vegetables were cooked until tender and compared as to color, odor, and flavor. Vegetables were weighed after soaking and after cooking and the increase in weight noted. The extent to which a vegetable took up water during soaking and cooking was considered an indication of the extent to which it returned to its plump fresh condition; other things being equal, the ones which took up the most water gave the tenderest, most attractive product. The results are as follows:

Beets soaked over night and cooked had an excellent flavor, and a color that was a little dark but not unattractive. With a shorter soaking period it was difficult to cook tender and the finished product had a shrivelled appearance. For each cup of dried beets, use 5 cups of water; soak over night and cook in the same water. Dried beets might very well be used in place of fresh beets in any recipe.

Beet Greens can be satisfactorily cooked without soaking in either hot or cold water. They require twenty to thirty minutes cooking. The color of the finished product is rather dark, the flavor is good. Dried beet greens could be served plain with butter, creamed, or any other way in which the fresh cooked greens are used. They should be cooked in from 2 to 3 times their volume of water.

Dried Carrots were most satisfactory when soaked over night in 6 to 8 times their volume of water. The finished product under these conditions is of good color, good shape, and resembles fresh carrots. However, the flavor is queer, being sweeter than the fresh carrot. If the carrots are soaked for shorter periods they have a shriveled appearance and the color is dark. While the flavor of the dried carrots is not distinctly disagreeable, yet it is so different from that of the fresh vegetable that the taste would have to be acquired. The flavor is strong enough to be noticed even when the carrots are used in a vegetable soup.

Onions. It did not seem to make much difference whether the onions were soaked a long or short time, except that it was easier to get a tender product if the material had been soaked at least one hour. The color of the cooked onions was fair, being slightly dark, the flavor was mild and very good. Dried onions would be suitable for use either as flavoring in soups, stews, etc., or as a dish by themselves. Since they could be used without soaking, it seems that their employment in the flavoring of cooked dishes would be very practical.

Green Peppers should be soaked over night in eight times their volume of water. The finished product is dark in color, resembling an over cooked string bean. The skin on the pepper is apt to be tough and the flavor rather strong. Their use would probably be very practical.

The Pimentos seemed slightly superior in color and tenderness when soaked overnight before being cooked, although the difference was not great. The finished product does not have the bright red color of the fresh pimento, and since this pepper is chiefly used as a garnish because of its color, the dried product could scarcely take the place of the canned pimento. However, one often wants only a little pimento, hardly enough to justify the opening of a can, and in that case a supply of dried material might be useful. Dried pimento might be powdered and used as a pepper. The flavor is mild.

Okra seemed to give the most satisfactory dried product of all. It can be cooked in either hot or cold water without soaking. Four parts of water to one of vegetable should be used, and the cooking period is 20 to 30 minutes. The finished product has a good appearance and is less slimy than the fresh okra when cooked. The dried material could be substituted in any of the recipes for fresh okra. Incidentally, okra was the easiest to dry of all the vegetables tried; its open structure allowed the moisture to escape quickly and uniformly.

Cabbage can be cooked without a soaking period but is slightly more tender when soaked one or two hours. The color is dark, and the flavor mild. The color makes it unattractive when served alone, so that dried cabbage would find its best use in soups.

Tomatoes did not produce a very satisfactory dried product. There was an odd flavor which might not be objectionable in soups, but which would make the use of tomatoes as a separate dish impossible. It was noticed that the disagreeable flavor developed as the tomatoes were kept, and the odor became increasingly sour. It was difficult to soften the tough skins by cooking, and it would probably be necessary to strain the material before using for soups.

Potatoes were thoroughly unsatisfactory in color, flavor, texture and form.

Of the vegetables studied okra gave in all respects the most satisfactory dried product, with beets ranking second and onions and beet greens coming next. The stems of the beets could not be included with the leaves because they did not cook satisfactorily. The carrots presented such an attractive appearance dried, and even after soaking, that it was a distinct disappointment to find that their flavor was so unsatisfactory.

The tomatoes dried more slowly than the other vegetables even when sliced quite thin, so that they probably became a little sour during the process. However, tomatoes can be so easily canned that one would probably never wish to dry them.

CONCLUSIONS

We feel that our brief experiments have demonstrated that some vegetables can be satisfactorily preserved in Oklahoma by sun-drying. Our study has not been exhaustive but we hope it has been suggestive, and that it will encourage housewives who have gardens, to try out the drying of vegetables under their own local conditions. Drying racks might be set up in a variety of places, wherever freedom from dust, and a good exposure to the sun can be obtained. Racks should not be placed flat on the ground because of the moisture which tends to collect underneath. Our arrangement, where the racks were attached to the side of the building, proved very convenient. Kitchen window ledges would be good locations for drying racks, where the material could be reached easily by raising the window. The vegetables which we included in our study were those which happened to be available at the time; but there are a number of others which might dry well.

Since vegetables lose at least four-fifths of their weight and a great part of their bulk when they are dried, about five times as much food measured on the fresh basis can be stored away in a given space if it is dried as if it is canned. The saving in space is often an important item. Another convenience in the use of dried material is the fact that a container may be opened and a little taken out and the rest replaced; whereas with canned goods one must use the whole can. Another point of convenience is the fact that dried vegetables can be stored in a variety of kinds of containers, a point of importance when the supply of glass cans is limited.

Dried vegetables are not subject to the same kinds of spoilage as canned vegetables. But they may mold unless thoroughly dried to start with, and stored in a dry place; and they must be carefully protected from insects, and looked over occasionally. It is also questionable whether sun-dried material will keep in a palatable condition as long as canned goods, but it should be possible to keep it all through the succeeding winter, and much longer than stored vegetables can be kept at the best.